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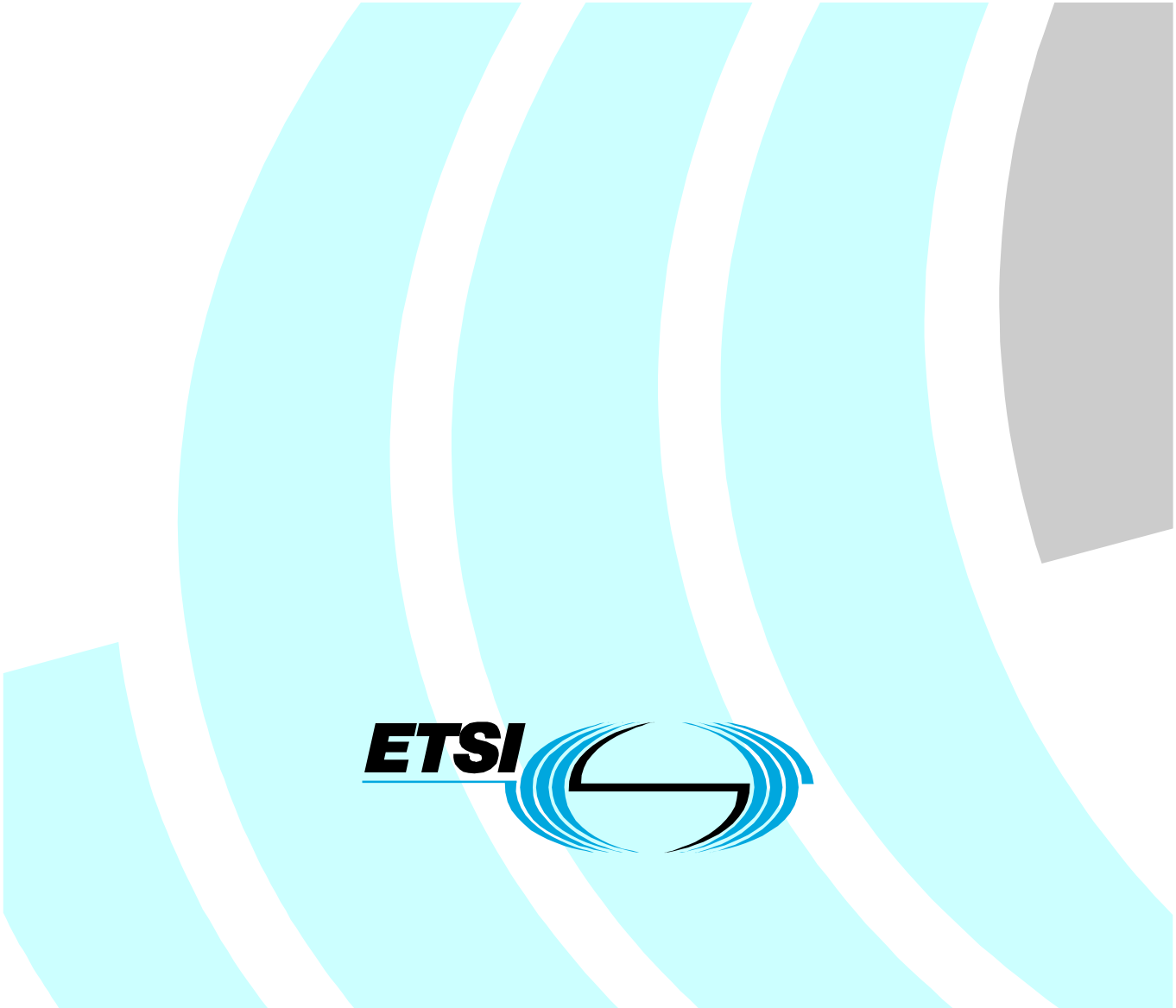
Technical Report

Fixed radio transmitter sites; Exposure to non-ionising electromagnetic fields; Guidelines for working conditions



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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Telecommunications Equipment Safety (Safety).

Under Mandate M/305, ETSI is contributing, with CENELEC, to a number of initiatives aimed at establishing standard test methods, test equipment and calculation methods for determining various aspects of electromagnetic fields generated by apparatus included within the scope of the Low Voltage Directive 73/23/EEC and the Radio equipment and Telecommunications Terminal Equipment (R&TTE) Directive 1995/5/EC.

Some ETSI member companies have perceived that, at the end of these joint initiatives, there will remain a requirement for a common approach to the management of occupational exposure to electromagnetic fields generated by such equipment when combined into a system and connected to antenna arrays at broadcast and telecommunications installations.

Introduction

The present document is relevant for people working at fixed radio transmitter sites where the electromagnetic fields may exceed levels defined by the Relevant Recommendations for the General Public.

These guidelines are intended to be used in areas where, due to the presence of active transmitter antennae, there are electromagnetic fields present. These guidelines are intended to provide a level of safety from the effect of EM Fields for such persons.

The present document describes different methods, all of which are equally valid, to ensure safety when working in the area of transmitting antennae:

1) Method 1: Field Monitor;

2) Method 2: Limit Distance;

3) Method 3: Zoning.

The three exposure assessment methods ensure that those working at sites are not exposed to Electromagnetic fields above the levels defined by the Relevant Recommendations (see clause 5).

Method 1 is an "Exposure Assessment" method based on the principle that the workers check for themselves the possibility of exposure based on the use of a field monitor. This method is applicable to any site where the exposure levels are unknown. This method is only applicable to trained personnel.

Methods 2 and 3 deal with defining a particular site in terms of where it is safe to enter and on what terms, based on field strengths present.

Method 3 has been introduced to cover more difficult situations, for example where a large television transmitter is present with other transmitting systems. Certain sites require accurate definition of the field strengths (or SAR) at different areas around the antenna in relation to the reference levels (or basic restrictions).

It is the intention of the present document to be in harmony with the current practice of work and not to force telecommunications operators, manufacturers or broadcasting companies into incurring extra costs due to large-scale redefinition of working practices or redefinition of antenna sites.

1 Scope

The present document gives guidance for workers at fixed radio transmitter sites where the electromagnetic fields in the frequency range from 9 kHz up to 300 GHz may exceed the levels defined for the general public either in the ICNIRP guidelines [1] or in the guidelines laid down by European or National Authorities.

The present document is not applicable where the exposure levels outside the equipment enclosures are less than the levels in the Relevant Recommendations. Transmitter sites used exclusively by radio amateurs are not covered by the present document.

2 References

For the purposes of this Technical Report (TR), the following reference applies:

[1] International Commission on Non-Ionising Radiation Protection - Guidelines for limiting exposure in time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz), Health Physics Volume 74, Number 4, April 1998, pp. 496-522.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply.

Basic restrictions: restrictions on exposure to time-varying electric, magnetic and electromagnetic fields

NOTE 1: Depending on the frequency of the field, the physical quantities used to specify these restrictions are current density (J), specific energy absorption rate (SAR) and power flux density (S). There are two sets of Basic Restrictions; one defining occupational levels (e.g. for workers) and one defining levels for the general public.

EM Worker: See Worker.

Exposure: occurs whenever a person is subjected to electric, magnetic or electromagnetic fields or to contact currents other than those originating from physiological processes in the body or other natural phenomena

Partial body exposure: result when fields are non-uniform over volumes comparable to the whole human body

Fixed radio transmitter site: site comprising one or more radio transmitters connected to one or more antennas, mechanically supported typically by poles, walls, masts or towers

NOTE 2: The site may be at ground or sub-surface level or erected on any part of a suitable building. The radio transmitters may be used for broadcasting, telecommunications or any other services.

NOTE 3: Sites solely installed with one or more very low power transmitters which cannot generate, by calculation, an exposure level exceeding the Relevant Recommendations at any close distance from its radiating antenna are excluded for the purposes of this report. (See clause 1.)

General public: all persons not classified as Worker

Limit distances: physical distances from an antenna within which the basic restrictions are exceeded

NOTE 4: Also known as limit boundary or compliance boundary.

Non-EM Worker: See Worker.

Site: specific location where one or more fixed transmitting antennas are present

Reference Levels: due to the fact that SAR values (and thus compliance with the basic restrictions) can be difficult to determine, derived Electric fields (E), magnetic flux density (B), Power flux density (S) and Magnetic (H) field values have been defined in the Relevant Recommendation

NOTE 5: These reference levels are also defined for both workers and the General Public.

NOTE 6: Reference level limits tend to be stricter than the basic restrictions which may result in situations where calculated values may exceed the reference levels but where the basic restrictions are not exceeded.

Relevant Recommendations: either the ICNIRP guidelines [1]or the guidelines laid down by European or National Authorities.

NOTE 7: The Relevant Recommendations may contain two separate sets of exposure limits, one applicable for the General Public and one applicable for Workers. Where reference is made in these guidelines to the Relevant Recommendations the appropriate set of limits should be used. In the absence of National exposure limits for Workers, it is recommended that the ICNIRP Occupational limits should be used rather than the National exposure limits for the General Public.

Specific Absorption Rate (SAR): time derivative of the incremental energy absorbed by an incremental mass contained in a volume element of a given mass density

NOTE 8: It is expressed in units of watts per kilogram (W/kg).

Six-minute rule: allows to temporarily exceed the basic restriction and reference levels as long as the averaged values over any continuous six-minute period remains under the specified limit. Further details are given down in ICNIRP guidelines [1]

Worker: person who may be occupationally exposed to EMF above the limits applicable for the General Public and who has received instructions according to the Relevant Recommendations

- **EM Worker**: worker with advanced training (e.g. working for the telecommunications operator or manufacturer of the base station, or broadcast company) who understands the potential risks of EMF at a site and is capable of assessing the associated risk and taking the necessary precautions to ensure safety. Such a person will have been trained with regard to the potential risks regarding exposure to EMF, see clause 4.2.1.

- **Non-EM Worker**: worker who has received basic training or instructions with regard to the precautions that need to be taken during the course of his duties. See clause 4.2.2.

Zone: area within an antenna site where the exposure of human beings falls within, or can exceed, basic restrictions or reference levels as defined in the Relevant Recommendations

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply.

EM	ElectroMagnetic
EMF	ElectroMagnetic Field
ICNIRP	International Commission on Non-Ionizing Radiation Protection
RF	Radio Frequency
SAR	Specific Absorption Rate

4 General Policies

4.1 General Position

- It is the intention that no-one will be exposed to EMF at levels exceeding those stated in the Relevant Recommendations. Access for the general public to areas exceeding the Relevant Recommendations should be prevented.

- Workers may be exposed, during the course of their duties, to field strength values up to occupational exposure limits as defined in the Relevant Recommendations.
- The six-minute rule always applies to exposure to EM fields.
- The measurement uncertainty should be known in all cases and should be taken into account as defined in the relevant standards.

NOTE 1: CENELEC TC211 is drafting standards for mobile base stations, broadcast transmitters etc. These standards will provide more information on measurement methods, including how to deal with measurement uncertainty.

- EMF measuring instruments, personal protection devices and protective clothing should be available for use by the EM worker if necessary (e.g. changes have been made to the installation and it is not certain whether the field strengths have changed). Induction current meters should also be available if needed. All equipment should be calibrated and in full working order according to their specifications.

NOTE 2: For high powered (e.g. broadcast) transmitters below 110 MHz, contact with metal devices may lead to induction and contact currents, see the Relevant Recommendations.

- If the radiation from an antenna needs to be reduced or switched off completely, such an action should be carried out only after prior agreement from the operator. After switching off a transmitter, it should be verified that the antenna is no longer radiating.
- A transmitter should only be switched back on once it has been determined that to do so would not endanger persons present on the site.
- The presence of any worker on a site should be logged.
- Information signs on how to obtain further advice should be placed at conspicuous points.
- Workers with personal active medical devices and active medical implants should inform their employer. The employer should then take the appropriate measures to protect the worker.
- Sites should be designed to minimize the accessible areas exceeding the levels specified in the Relevant Recommendations. An example of this is to take the height of the antenna into consideration.
- A site may only be accessed if it has been assessed according to clause 5.

4.2 Classification of workers

To qualify as an EM worker or non-EM worker, training and/or instructions should be given as defined in clauses 4.2.1 and 4.2.2 respectively.

4.2.1 EM workers

Appropriate training for EM workers should include at least the following:

- Being brought up to date on Relevant Recommendations and understanding the potential exposure risks.
- Instruction on the operation of all necessary measuring instruments/equipment and
- Interpretation of instrument indications/measurement results.
- Instruction on relevant personal protection aids/monitors (these are described clause 5).
- Knowledge of access procedures.
- Actions to be taken in cases of suspected exposure exceeding the Relevant Recommendations (see clause 4.2).

4.2.2 Non-EM Worker

The following applies for non-EM Workers:

- The individual in question must be provided with appropriate instructions. These should include information about precautions, access procedures and the potential risks from exposure to EMF.
- Non-EM Worker classification is only valid for the period that the worker works at the radio site. It may be that non-EM Workers who are often present at sites do not need the full instruction every time.

4.3 Actions to be taken in cases of suspected exposure exceeding the Relevant Recommendations

Processes should be put in place that define the procedures to be followed in the case of suspected over-exposure. This should form part of the EM workers training course.

- If an incident occurs, or if there is cause to believe that a person has been exposed to levels exceeding the Relevant Recommendations, then that person should immediately leave the site (after securing the site if that person is unaccompanied).
- Persons suspected to have been exposed to EMF exceeding the levels of the Relevant Recommendations should seek appropriate medical advice.
- A reassessment of the site should be carried out and the necessary corrective action(s) taken before continuing work.

5 Site characterization

To validate the exposure at an antenna site the following three methods are proposed.

NOTE: The benefits of protective clothing, if any, should be taken into account.

5.1 Method 1: Field monitor

Method 1 is based on the principle that field strength levels are unknown. This means that no calculations need to be carried out before entering a site. A field probe or monitor should always be used.

This method covers the situation where a site has either not been defined or has been defined but it is not certain if field strengths have changed or not. It can also be used where field strengths are generally known but the Limit Distance has not been determined. An exposure assessment must therefore be performed.

Equipment options for this purpose are described below. All equipment should be used in accordance with its operating instructions. Two slightly different methods of exposure assessment are then described.

Limitations of this method include the fact that appropriate measuring devices must correspond to the various frequencies present. This may mean carrying two or more instruments. This method may not be used if the frequencies are not known.

5.1.1 Types of field monitors

5.1.1.1 Personal monitors

Personal monitors provide a means of continuously monitoring the RF field to which an individual is actually exposed. They provide broadband coverage of a range of frequencies. More than one monitor could be required to cover all the frequencies present at multi-user locations for example, where Microwave, Cellular Telephone and VHF/UHF transmitters are present.

Personal monitors are ideally suited to multi-user sites, as they automatically provide a summation of the field components over the range of frequencies for which they are designed, and therefore provide an alarm trigger based on the equivalent power density of the combined fields. This eliminates the need for any complex measurements or calculations.

It should be noted that body worn personal field monitors may not provide adequate accuracy, due to the proximity of the body.

5.1.1.2 Area monitors

RF field strength can be continuously measured by an unattended area monitor linked to an alarm system.

5.1.1.3 Survey instruments

Survey instruments measure the electrical or magnetic components of RF fields. They can be used to pinpoint RF leakage from feeder cables and other sources, using probes that permit measurements in relatively inaccessible places. They also allow the detector to be physically separated and, if necessary, electrically de-coupled from the meter. Whenever measurements are carried out, they shall be made by EM workers.

5.1.2 Assessment by field monitors

The personal monitors described in clause 5.1.1.1 could be used to establish the RF field strength at a site. The equipment must be selected to give adequate coverage of the required range of power levels, frequencies, etc.

As there will generally be no locally available alternative method for cross-checking the results of RF field strength measurements, or any tangible indication of high levels, monitoring equipment must be used and re-calibrated strictly in accordance with the manufacturer's instructions, and only by competent persons.

For persons who are likely to work in areas with probable exposure to RF fields exceeding the Relevant Recommendations, a personal monitor may be a convenient option. This is because it provides a continuous, real time monitoring of the RF fields and the user can move freely in areas of varying and unknown RF field strength, knowing that the monitor will provide a warning before the reference level is exceeded. On receiving an alarm, the user should withdraw immediately to a safe area.

5.1.2.1 Exposure assessment

a) If field strengths are known but Limit Distances have not been calculated field strength values must be checked against the Relevant Recommendations. If values are judged by the EM worker to be below the Relevant Recommendations, work may proceed without taking any exposure precautions. For borderline values a personal monitor must be used. For values exceeding the Relevant Recommendations no entry is allowed without control measures being taken.

b) If field strengths are unknown consider whether the circumstances would justify carrying out a full RF survey (e.g. large number of antennae present or a powerful broadcasting antenna present). If so, implement this full RF survey to obtain information on field strengths and follow points c to e.

c) If it is shown by simple conservative calculations that the levels of the Relevant Recommendations are not exceeded, work may proceed without taking any exposure precautions.

d) In borderline cases, or where field strengths are unknown but judged not to be high enough to justify a survey, those working at the site must use personal monitors.

e) Assuming that there is always exposure above the Relevant Recommendations, then:

   - identify the range of frequencies present at the site;
   - select and issue the appropriate Personal Monitor for every employee likely to be exposed;
   - operate a "Stop work and review" policy to cover the occasions when an alarm is triggered on any monitor.

5.2 Method 2: Limit distances

Method 2 is based on limit distances. The company responsible of each antenna at a site should provide the limit distance for the relevant configuration. The limit distance information should be available on the site, this may be provided by signs. If the information is not available at the site it should be obtained by calling the company responsible for each antenna at the site.

NOTE: Relevant CENELEC, IEC and ITU standards or recommendations should be used for the evaluation of the limit distances where these are applicable.

The presence of other radiating antennae in the vicinity of the site should be taken into account when determining the Limit Distances. The ICNIRP guidelines give the formulas which can be used when evaluating the exposure by fields containing more than one frequency component.

5.3 Method 3: By zoning

The concept of a "Zone" is used to simplify the treatment of EMF and clarify the potential exposure when entering a particular area. Zoning is achieved by comparing the measured values to the limits and categorizing the values according to the safety aspects that need to be adhered to. These different categories are defined using a marked Zone scheme. Definition of a particular Zone is linked to the transmitter output power and the antenna(e). Any changes made (e.g. new antenna, changes in output power) may affect the Zone category.

This method requires a number of measurements or calculations to be carried out since SAR or field strengths must be determined. Most of the calculations can be made using numerical analysis tools. These tools require consideration of a number of parameters (such as emitted power, measuring distance, distance between antennae, vertical height etc.). (E), (H) or (S) field or SAR values and patterns are then calculated numerically. Numerical analysis avoids carrying out lengthy measurements and can produce quick and accurate results. There may be situations where owing to complicated field patterns actual measurements will have to be carried out.

In defining the different Zones it is possible to use calculated SAR values (and therefore corresponding SAR basic restrictions) instead of field strength calculations (and corresponding reference levels). The exposure restrictions are defined in two sets of limits:

- those based on an average exposure over the whole body (total body exposure);
- those which allow for a higher absorption of energy when only parts of the body are exposed (partial body exposure). This set is further subdivided into limits for the head, neck and trunk, and limits for the limbs.

The reference levels however do **not** distinguish between total body exposure and partial body exposure. Compliance to the reference levels as the maximum value over the entire body ensures that basic restrictions on total and partial body exposure are satisfied. They may be averaged values over the entire body with the emphasis being on the fact that the basic restrictions on localized exposure are not exceeded.

The zone definition below is based on wording and may be identified by numbers or characters. For the purpose of the present document, they are marked with A, B, C and D.

5.3.1 Zone definition based on exposure levels (SAR, (S), E, and (H)-field)

Zone A:

Total or Partial body exposure values exceed the Relevant Recommendations for workers.

Zone B:

Total or Partial body exposure values exceed the Relevant Recommendations for workers at some point in space and time but when averaged out (e.g. six-minute rule by spatial moving) levels **do not exceed** the Relevant <Recommendations.

NOTE 1: The term "six minute rule by spatial moving" describes the situation that part of a body can be highly exposed but for a limited time. If someone keeps walking/moving, the averaging, by applying the six minute rule, results in the exposure below the Relevant Recommendations for workers for the total and partial body. If the person stands still the partial body exposure will may exceed the Relevant Recommendations for workers. If the presence in zone B is limited for a time period less than six minutes, then time averaging should include provisions related to actual exposure levels in neighbour Zones C or D.

Zone C:

Both partial and total body exposure values are below (or within, or compliant to) the Relevant Recommendations for workers.

Zone D:

All exposure values are within the Relevant Recommendations for the general public.

NOTE 2: Zone D may fall between other zones and therefore needs a definition.

5.3.2 Site access classification

A site may consist of a number of discrete "sub-sites". Each sub-site will be allocated what is termed an "access level". The objective of assigning an access level to the various sub-sites is to clearly define who is allowed to enter and under what conditions. Four different access levels have been defined. The definition of an access level is based on the types of zone present:

- **Access Level 3:** this consists of at least one Zone A. There may also be Zones B, Zones C or D present;
- **Access Level 2:** this consists of at least one Zone B. There may also be Zones C or D. There are no Zones A present;
- **Access Level 1:** this consists of at least one Zone C. There may also Zones D present. There are no zones A and B present;
- **Access Level 0:** the whole sub-site has been assigned a Zone D (and does not need to be marked further).

The Access Levels are therefore assigned according to the most limiting Zone present in the sub-site.

Access to sites with an Access level greater than 1 need to be controlled (e.g. locked door or a fence) and labelled. Warning symbols need to be placed at the entrance to these levels.

For Access Levels 3 and 2 labelling of the access level is required.

6 Access management

6.1 On-site information

The main purpose of the on-site information is to give information about the characterization of the site. When following one of the three methods defined in clause 5, at least the following on site information should be provided:

- Contact information of the company responsible for each antenna at a site.
- Signage of areas with restricted access for both the General Public and Workers.

6.2 General Access Conditions

1) If zoning information is available, the EM workers must make use of the different Zones and Access Levels when working at a site or before accompanying a non-EM Worker.

2) In situations where no valid zoning information is available or it is thought to be out of date no entry is allowed into an area without a field measurement / (or SAR) calculation being carried out. Measurements or calculations made for the head and trunk level must be used as determining factors.

3) Non-EM Workers must have authorization to work at a site.

6.3 Access conditions related to the assessment method

6.3.1 Access condition by using a Field monitor (Method 1)

EM workers may only enter those areas where the field monitor indicates that the Relevant Recommendations for workers have not been exceeded.

Non-EM Workers are only allowed to access a site using a field monitor under the instruction and supervision of an EM worker.

6.3.2 Access condition by using limit distances (Method 2)

- When limit distance for workers (see clause 5.2) falls within the equipment enclosure of the antenna then there are no restrictions.

- Workers are not allowed to have access to the area defined by the limit distances for workers.

6.3.3 Access condition by using zones and access levels (Method 3)

6.3.3.1 Access conditions for areas with access level 3

1) No entry is allowed to Zones A without taking precautionary measures (e.g. protective clothing, power reduction). Such precautionary measures must ensure that exposure above the Relevant Recommendations for workers does not occur.

2) Entrance is allowed to a Zone B under the condition that the EM worker follows the on-site specific instructions in order to remain below the basic restrictions of the Relevant Recommendations. These instructions related to spatial or time averaging rules are defined by the company responsible for the site (e.g. keep moving, stay less than 1 minute, etc.).

3) Non-EM Workers may only enter a site with access level 3 under the supervision and instruction of a EM worker.

6.3.3.2 Access conditions for areas with access level 2

1) Entrance is allowed to a Zone B under the condition that the EM worker follows the on-site specific instructions in order to remain below the basic restrictions of the Relevant Recommendations. These instructions related to spatial or time averaging rules are defined by the company responsible for the site (e.g. keep moving, stay less than 1 minute, etc.).

2) Non-EM Workers may only enter under the supervision and instruction of a EM worker.

6.3.3.3 Access conditions for areas with access level 1

Workers have no access restrictions.

6.3.3.4 Access conditions for areas with access level 0

No condition apply.

History

Document history		
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